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HUMPBACK CHUB (*GILA CYPHA*) IN THE YAMPA AND GREEN RIVERS, DINOSAUR NATIONAL MONUMENT, WITH OBSERVATIONS ON ROUNDTAIL CHUB (*G. ROBUSTA*) AND OTHER SYMPATRIC FISHES

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ABSTRACT.—We evaluated distribution, habitat use, spawning, and species associations of the endangered humpback chub (*Gila cypha*) in the Yampa and Green rivers, Dinosaur National Monument, from 1986 to 1989. Adult and juvenile humpback chub were captured in high-gradient reaches of Yampa and Whirlpool canyons where they were rare (n = 133, <1% of all fish captured). The fish was primarily captured in eddy habitats in association with 7 native and 12 nonnative fish species. Roundtail chub (*G. robusta*) were widely distributed in eddies, pools, runs, and riffles. Humpback chub (n = 39) and roundtail chub (n = 242) in reproductive condition were sympatric in eddy habitats during the 5–6-week period following highest spring runoff. River temperatures at this time averaged about 20 C. Nonnative channel catfish (*Ictalurus punctatus*) were abundant in eddies yielding humpback and roundtail chubs, suggesting a potential for negative interactions between the native and introduced fishes.

The humpback chub (*Gila cypha*), a large-river cyprinid endemic to the Colorado River basin of western United States, is federally protected by the Endangered Species Act of 1973. The fish persists only in isolated locations, including canyon reaches in the Little Colorado and mainstream Colorado rivers, Arizona (Kaeding and Zimmerman 1983), upper Colorado River, Colorado (Valdez and Clemmer 1982, Kaeding et al. 1990), Green and Yampa rivers, Colorado and Utah (Holden and Stalnaker 1975a, 1975b, Tyus et al. 1982), and mainstream Colorado River, Utah (Valdez 1990). All stocks are presumed native except in Cataract Canyon of the Colorado River, Utah, where some fish may be derived from a 1981 stocking of juvenile fish of upper Colorado River (Black Rocks) parentage (J. Valentine, personal communication).

Distribution and status of humpback chub in the upper Green and lower Yampa rivers in Dinosaur National Monument (DNM) remain poorly documented, partly because canyon-bound whitewater habitats are difficult to access and sample, the fish is rare, and diagnostic features are not well established. Humpback chub were first reported in DNM in the 1960s, and most captures occurred in the confluence area of the Yampa and Green rivers (Holden and Stalnaker 1970, 1975a, 1975b, Vanicek et al. 1970). Studies in the mid–1970s and early 1980s also noted the paucity of the fish in DNM (Seethaler et al. 1979, Miller et al. 1982).

Roundtail chub (*Gila robusta*) are sympatric with humpback chub in DNM but are more widely distributed and more abundant (Banks 1964, Vanicek et al. 1970, Holden and Stalnaker 1975, Miller et al. 1982). The fish is not considered threatened or endangered under the Endangered Species Act of 1973. Remains of *Gila* species in Indian sites in DNM dating more than 1000 years old (Leach 1970) suggest that chub were presumably eaten by Native Americans and thus have been present in the area for a long time.

This study was initiated as part of a larger program to assess status and habitat needs of endangered fishes in the Yampa River (Tyus and Karp 1989). Our objectives were to locate humpback chub in DNM and, if successful, evaluate habitat use (including flow and temperature requirements), identify spawning areas, and determine species associations.

METHODS

The lower 73.6 km of the Yampa River (i.e., Yampa Canyon: Deerlodge Park to Echo Park; Fig. 1) was sampled weekly from mid-May through early July 1987–1989 by electrofishing and angling with native foods (e.g., Mormon crickets [*Anabrus simplex*] and megalopteran larvae) and night crawlers at various locations in the water column. Echo and Island parks and Whirlpool and Split Mountain canyons of the Green River were sampled

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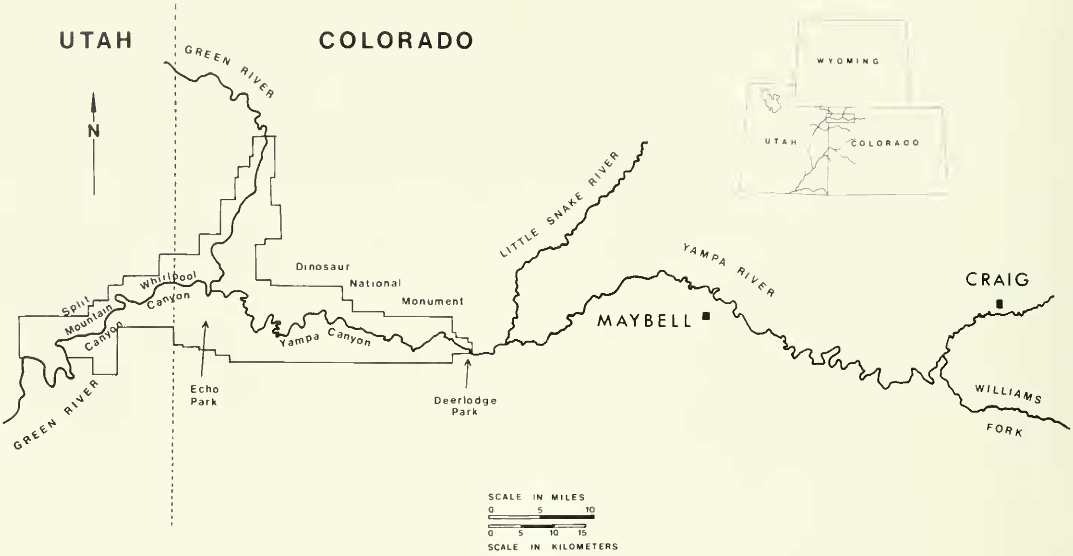

Fig. 1. Yampa and Green rivers, Colorado and Utah, showing the boundaries of the study area and Dinosaur National Monument.

at least twice each spring in 1987 and 1988, and Lodore Canyon (Green River) was sampled once each spring. Survey sampling (including trammel netting) was conducted throughout the Monument in July 1986 to locate humpback chubs. Use of trammel nets was discontinued after this effort because of trauma to the fish.

Sampling trips in Yampa Canyon occurred at weekly intervals (preceding and following first and last capture of ripe fish) to insure an accurate assessment of the humpback chub spawning period. Our efforts were less intensive in the Green River portion of the Monument because earlier sampling had yielded few adult chubs in these reaches (Holden and Crist 1981, Miller et al. 1982). Sampling preceded peak flows and was suspended during highest runoff (2–4 week period depending on water year) because of sampling problems in high water. Sampling ended each summer with attainment of base flows (approximately late June to early July). Our efforts were restricted to the spring and early summer because of boat accessibility. However, two areas in Yampa Canyon that yielded humpback chub in the spring (Big Joe Rapid and vicinity, Warm Springs Rapid and vicinity) were sampled in September 1989 via helicopter and by foot to assess habitat availability, use, and substrate composition during low flows.

All chubs greater than 85 mm total length (TL) were identified to species using established morphological characters (Smith et al. 1979, Douglas et al. 1989). We did not evaluate habitat use of young humpback chub because we could not reliably distinguish young of the various *Gila* species. Humpback chub greater than 250 mm TL were tagged with uniquely numbered Carlin-dangler tags for recapture information (e.g., growth and movement data). Sex determination was based only on expression of eggs or milt from ripe fish, either spontaneously or following manual pressure on the abdomen. Fish with breeding tubercles but without expressible sex products were considered in reproductive condition.

Riffles, small rapids, runs, eddies, pools, and backwaters were sampled. Because water turbidity precluded visual contact with humpback chub, it was necessary to estimate the point of capture. Physical habitat parameters recorded at each humpback chub capture included water depth, temperature, and substrate type. Depth was measured with a calibrated rod, gross substrate type was described from visual and manual examination, and temperatures were obtained with hand-held thermometers (methods after Nielsen and Johnson 1983). We did not attempt quantification of water velocities because most humpback chub were captured in habitats where water currents swirled in both upstream and downstream directions and initial efforts with a flow meter yielded a wide range of positive (upstream) and negative (downstream) velocities. Habitat use data was not recorded for species other than humpback chub. River flows were obtained as daily averages from the U.S. Geological Survey gauging station at Deerlodge Park, Yampa River (Fig. 1). Stream gradient was obtained from U.S. Geological Survey stream profile maps.

Data Analyses

Capture data were analyzed by total catch (all years, all gear types, and sampling) and standardized catch (1987–1989: catch of all species and effort recorded for each sample). Total catch data were used to describe general fish distribution, and standardized data were used to evaluate relative abundance. Standardized catch data were summed by gear (i.e., angling or electrofishing) and for each river reach (i.e., Yampa, Lodore, Whirlpool, and Split Mountain canyons, Echo and Island parks), and catch per unit effort (C/f) was calculated by dividing numbers of fish captured by effort. Angling and electrofishing data from 1986 were not included in C/f estimates because numbers of fishes other than chubs were not recorded and because of significant differences in angler ability. Trammel netting C/f was not reported because of limited use. Electrofishing was biased toward catch of larger individuals, and small fishes (e.g., nonnative reside shiner [*Richardsonius balteatus*] and native mottled sculpin [*Cottus* spp.]) and juveniles of larger species were not recorded because they often slipped through our 1-in^2 mesh dip-nets. Angling efforts in September 1989 were excluded from the C/f estimates because this effort represented a unique fall sample. Sampling was initiated late in 1986, and those data were excluded from our evaluation of spawning period.

RESULTS

Distribution and Habitat Use

HUMPBACK CHUB.—Humpback chub were collected only in whitewater reaches of Yampa (n = 130) and Whirlpool (n = 3) canyons (Fig. 1). The Whirlpool Canyon fish were captured in the same location, about 6 km downstream of the confluence with the Yampa River. No other humpback chub were captured in the Green River. Humpback chub constituted 7.3% (n = 51) of the standardized angling and <1% (n = 58) of the standardized electrofishing catch. They were most abundant (85% of all humpback chub captures, n = 113) in the upper 44.8 km of Yampa Canyon, a moderately steep-gradient section (3.2 m/km) dominated by rocky runs, riffles, and rapids. Lower Yampa Canyon (km 0–28.8), a lower-gradient system (1.0 m/km) consisting mostly of long, deep runs and incised meanders, yielded relatively few humpback chub (n = 17).

During spring runoff, humpback chub were most often captured in larger shoreline eddies (20–100 m^2) that were either downstream of boulders or upstream of rapids, or in smaller eddies (<20 m^2) within shoreline runs. Adult fish (>230 mm TL; based on capture of the smallest ripe fish, a 232-mm-TL male) were consistently captured in, and apparently selected, seasonally flooded shoreline eddies (i.e., formed and maintained by spring runoff). These habitats were dominated by low or negative water velocities and influenced by river surges (i.e., water velocities at any particular point varied in magnitude of up- and downstream currents). Substrate consisted mostly of sand and boulders, and water depth averaged 1.3 m at the estimated point of capture. Humpback chub were not collected in riffles and rapids.

Eleven of 76 Carlin-tagged humpback chub ($\bar{x}$ = 312 mm TL, SD = 19) were recaptured one week to two years after initial capture (5 within a year, 6 from one to two years). Ten fish were recaptured in the immediate vicinity of their original capture, and one was collected about 8 km downstream from its initial capture site. Eight fish (73%, n = 11) were recaptured in breeding condition on at least one occasion. We detected no growth in recaptured fish.

About 22% (n = 29) of humpback chub were juveniles (88–228 mm TL). These were most often captured by electrofishing in rocky shoreline runs and small shoreline eddies. One juvenile (122 mm TL) was taken from the stomach of a 61-cm-TL garter snake (*Thamnophis* species) caught at the confluence of the Yampa and Green rivers.

ROUNDTAIL CHUB.—A total of 1482 roundtail chub were captured in all reaches of DNM except Split Mountain Canyon and the upper 29 km of Lodore Canyon. The fish constituted 37% (n = 256) of the standardized angling and 15% (n = 1016) of the standardized electrofishing catch. Roundtail chub were at least three times more abundant in Yampa Canyon than in the DNM portion of the Green River (Tables 1, 2) and were most prevalent in the upper 44.8 km of Yampa Canyon (73% of all roundtail chub captures, n = 1085). The fish was incidental in Lodore Canyon (<1%, n = 3). Adults and juveniles were most often captured in eddies, pools, and shoreline runs, but they were also taken in riffles and lower portions of rapids.

Species Associations of Humpback Chub

Humpback chub were captured in association with 7 native and 12 nonnative fish species (numbers of native sculpins and nonnative redside shiners not recorded). Species that dominated the standardized catch included flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*C. discobolus*), roundtail chub, common carp (*Cyprinus carpio*), and channel catfish (*Ictalurus punctatus*) (Tables 1, 2).

A total of 350 fish were captured by angling in eddies occupied by humpback chub. Roundtail chub composed about 45%, channel catfish 35%, and humpback chub 15% of this catch. More channel catfish were captured by angling than was any other species (n = 328, 47% of angling catch), and it was the most abundant nonnative fish in eddies that also yielded humpback chub. Other species, including Colorado squawfish (*Ptychocheilus lucius*), flannelmouth sucker, common carp, black bullhead (*Ameiurus melas*), and rainbow trout (*Oncorhynchus mykiss*), composed less than 5% of the angling catch. Electrofishing catch was dominated by flannelmouth (n = 2049, 29%) and bluehead (n = 1801, 26%) suckers, and these fishes were common in canyon habitats (Table 1) and open parks (Table 2).

The most abundant introduced fishes in DNM were common carp (n = 1321) and channel catfish (n = 1153). These species were relatively common in canyon-bound whitewater reaches and lower-gradient slow-water sections. Standardized C/f data indicated both were most abundant in Split Mountain Canyon (Tables 1, 2).

During September 1989, flows in Yampa Canyon were reduced to less than 2.83 m^3/s, and fish habitat was limited to shallow riffles (about 15-cm depth) and deeper pools and runs (about 1-m depth). On September 7 we collected five chubs (four roundtail and one suspected roundtail × humpback chub hybrid) and seven channel catfish in pools and eddies (about 1 m deep) in Big Joe Rapid (km 38.4). Other chubs, including a suspected humpback chub, were observed about 0.8 km upstream in a 1.1-m-deep pool created by shoreline boulders. No fish were observed or collected in the vicinity of Warm Springs Rapid (km 6.4) on September 14.

Spawning of Humpback Chub and Roundtail Chub

Thirty-nine humpback chub (16 ripe males, 5 ripe females, and 18 tuberculate but nonripe fish) were captured in shoreline eddy habitats in a 48-km reach (km 20.8–68.8) in Yampa Canyon (n = 37) and in a 2-km reach (km 545.6–547.2) in Whirlpool Canyon (n = 2). Turbidity precluded direct observation of the fish; thus, spawning behavior and microhabitat use were not documented.

All ripe fish were silvery colored with "gold flecks" on the dorsum. Ripe males always had some orange coloration on the lower side of the head, opercles, abdomen, and paired and anal fin bases. Ripe males and females usually bore light tuberculation on portions of the head, nuchal hump, opercles, and paired fins. This tuberculation was more robust in males. Ripe males averaged 311 mm TL (n = 16, SD = 35, range 232–370 mm) and 229 g (n = 14, SD = 67, range 130–348 g), ripe females averaged 300 mm TL (n = 5, SD = 20, range 280–333 mm) and 230 g (n = 4, SD = 75, range 160–336 g), and nonripe tuberculate fish averaged 303 mm TL (n = 18, SD = 35, range 232–382 mm) and 203 g (n = 17, SD = 62, range 92–356 g).

Ripe humpback chub were collected following highest spring discharges from mid-May to late June 1987 to 1989 (Table 3, Fig. 2). Captures of nonripe but tuberculate fish also occurred within this 5–6 week period (Table 3). Although sampling in 1986 did not include prerunoff conditions and thus was excluded from Figure 2, four humpback chub in

TABLE 1. Total catch (N) and catch per unit of effort of fishes collected by standardized angling (AN) and electrofishing (EL), 1987–1989, Yampa, Lodore, Whirlpool, and Split Mountain canyons, Dinosaur National Monument. Total effort in hours spent angling (angler hours) and electrofishing.

		Yampa Canyon		Lodore Canyon	Whirlpool Canyon		Split Mountain Canyon
Species	N	AN	EL	EL	AN	EL	EL
Native species							
Flannelmouth sucker	2,159	0.30	28.94	24.72	0.00	27.82	20.92
Bluehead sucker	1,812	0.01	22.35	14.43	0.00	31.96	83.67
Roundtail chub	1,238	3.25	17.09	0.28	1.02	2.66	0.00
Humpback chub	109	0.65	1.03	0.00	0.23	0.00	0.00
Colorado squawfish	27	0.01	0.30	0.28	0.00	0.53	1.02
Razorback sucker	4	0.00	0.07	0.00	0.00	0.00	0.00
Mountain whitefish	2	0.00	0.02	0.00	0.00	0.13	0.00
Introduced species							
Common carp	1,100	0.24	15.06	10.94	0.23	9.19	25.51
Channel catfish	1,091	4.01	9.64	1.79	2.61	8.26	71.94
Trout[a]	277	0.01	0.16	22.26	0.00	3.86	1.02
Black bullhead	31	0.11	0.21	0.09	0.68	0.4	0.51
Northern pike	15	0.00	0.18	0.00	0.00	0.13	2.04
White sucker	13	0.00	0.14	0.18	0.00	1.73	0.00
Smallmouth bass	6	0.00	0.11	0.00	0.00	0.00	0.00
Green sunfish	1	0.00	0.02	0.00	0.00	0.00	0.00
Total fish	7,885	653	5,349	795	42	641	405
Total effort[b]		76	56	11	9	8	2

[a]Includes rainbow, cutthroat, brown, and lake trouts.
[b]Rounded

TABLE 2. Total catch (N) and catch per unit of effort of fishes collected by standardized electrofishing (EL), 1987–1989, Island and Echo parks, Dinosaur National Monument. Total effort in hours spent electrofishing.

		Island Park	Echo Park
Species	N	EL	EL
Native species			
Flannelmouth sucker	185	26.37	26.34
Bluehead sucker	145	21.54	19.95
Roundtail chub	42	3.22	8.18
Mountain whitefish	1	0.32	0.00
Introduced species			
Common carp	125	19.29	16.62
Channel catfish	55	11.9	4.6
Trout[a]	16	0.64	3.58
Black bullhead	2	0.00	0.51
Northern pike	1	0.00	0.26
White sucker	1	0.32	0.00
Green sunfish	2	0.32	0.26
Total fish	575	261	314
Total effort[b]		3	4

[a]Includes rainbow, cutthroat, brown, and lake trouts.
[b]Rounded

TABLE 3. Capture dates of humpback and roundtail chubs in reproductive condition, Yampa and Green rivers, Dinosaur National Monument, 1986–1989.

	Ripe males	Ripe females	Tuberculate fish[b]
Humpback chub			
1986[a]	Jul 5–15	Jul 5	—
1987	May 20–Jun 29	May 18–Jun 16	May 18–Jun 22
1988	Jun 7–28	Jun 15	Jun 6–15
1989	Jun 7	—	May 27–Jun 6
Roundtail chub			
1986[a]	Jul 6–29	—	—
1987	May 18–Jun 20	May 17–Jun 23	May 17–Jun 29
1988	Jun 7–Jul 5	Jun 16	Jun 7–29
1989	May 27–Jun 7	Jun 20	May 22–Jun 20

[a]No sampling prior to July 5 in 1986.
[b]Tuberculate fish were not ripe but exhibited secondary sex characters.

breeding condition (two of each sex) were collected in July of that year. Ripe fish were captured at water temperatures of about 19.5 C (range 14.5–23 C).

Roundtail chub in reproductive condition ($n = 242$: 117 males, 6 females, and 119 tuberculate but nonripe fish) were darker than

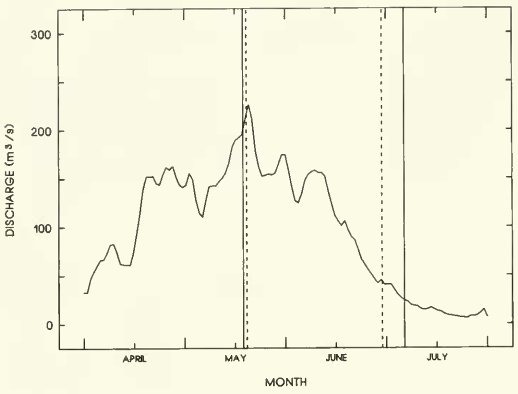

Fig. 2. Relationship between average distribution hydrograph and spawning period for humpback and roundtail chubs, Yampa River, 1987–1989. Dashed vertical lines delineate first and last capture of ripe humpback chub; solid vertical lines delineate first and last capture of ripe roundtail chub; 1986 not included because sampling was initiated late in spring runoff.

humpback chub and exhibited more robust tuberculation and more brilliant orange coloration. Patterns of tubercles and breeding coloration were similar between the two chubs. Ripe male roundtail chub averaged 344 mm TL (n = 117, SD = 24, range 292–419 mm TL) and 329 g (n = 100, SD = 84, range 190–652 g), and ripe females averaged 363 mm TL (n = 6, SD = 15, range 343–380 mm TL) and 363 g (n = 3, SD = 104, range 276–478 g). Nonripe tuberculate fish averaged 351 mm TL (n = 119, SD = 29, range 264–447 mm TL) and weighed about 364 g (n = 77, SD = 123, range 140–844 g).

Ripe roundtail chub were captured in pools and shoreline runs and eddies during the period of declining spring runoff (Fig. 2). Humpback and roundtail chubs in breeding condition were collected syntopically on 13 occasions. Although this indicated overlap in use of shoreline eddies during spring runoff, ripe females of both species were not syntopic.

Discussion

Humpback chub and roundtail chub were sympatric in DNM in the reach from upper Yampa Canyon to upper Whirlpool Canyon, although humpback chub were rare (<1% of total catch and only 8% of the two *Gila* species combined). Humpback chub were most prevalent in, and presumably selected, eddy habitats in moderate- to steep-gradient reaches, whereas roundtail chub were ubiquitous in parks and most canyons in eddies, riffles, and runs. Both fishes were most abundant in Yampa Canyon; neither was captured in Split Mountain Canyon, and the humpback chub was absent and the roundtail chub rare in Lodore Canyon.

The paucity of Colorado River chubs in Split Mountain and Lodore Canyon reaches indicates a general decline of *Gila* species relative to earlier decades (e.g., Banks 1964, Vanicek et al. 1970, Holden and Stalnaker 1975a). This may be related to the loss of historic temperature and flow regimes due to regulated flow releases from Flaming Gorge Dam, and to the proliferation of nonnative fishes, particularly channel catfish and common carp. The current rarity of Colorado River chubs in Split Mountain Canyon was also noted by the authors in 10 hours of opportunistic sampling and by the State of Utah during their 1988–89 studies (T. Chart, Utah Division of Wildlife Resources, personal communication).

Capture of 133 humpback chub, including 39 breeding adults and 29 juveniles, indicates that a reproducing population exists in Yampa Canyon. However, only one ripe fish, a male, was collected in the Green River (i.e., Whirlpool Canyon), and it is unknown whether it spawned there or was a stray from the Yampa River. Collection of ripe roundtail chub in canyon reaches yielding ripe humpback chub indicates some temporal and spatial overlap in habitat use during the spawning period, as observed by others in the upper Colorado River (Kaeding et al. 1990).

Ripe humpback and roundtail chubs were collected during declining spring flows and increasing river temperatures after highest spring runoff. This occurred in May and June in low- (e.g., 1987, 1989) and average- (e.g., 1988) flow years but extended into July in the 1986 high-flow year. No humpback chub in breeding condition were captured during prerunoff and late postrunoff periods, and we presume the fish spawned only during the 5–6 week period following highest spring flows. Capture of only a few ripe female chubs (five humpback and six roundtail chubs, 4% of all breeding captures) suggested that females may be ripe for a limited time. Ripe humpback chub were captured at temperatures ($\bar{x}$ = 19.5, range = 14.5 –23 C) that approximate optimum egg incubation conditions (i.e., 20 C; Marsh 1985). These temperatures are similar to the 14–24 C range noted by Kaeding et al. (1990) but slightly higher than the 11.5–16 C temperatures noted by Valdez and Clemmer (1982), both in the upper Colorado River.

All humpback chub and most roundtail chub in breeding condition were captured in shoreline eddies. Our recapture data indicate that adult humpback chub remain in or near specific eddies for extended periods and that they return to the same eddy during the spawning season in different years (i.e., they exhibit a fidelity to a specific site). Ten of the 11 recaptures were captured in the same eddy as the initial capture (50% in two different spawning seasons), and 73% were captured in breeding condition at least once. We do not know whether these fishes deposited eggs in these eddies or used such habitats only for staging, resting, or feeding. However, we consider the use of such habitats as part of the breeding requirements of humpback chub in the Yampa River. Shoreline eddy habitats in Yampa Canyon were ephemeral (i.e., disappeared with declining summer flows), and it was obvious that the fish moved elsewhere after the spawning period. Our observations of *Gila* species in pools near Big Joe Rapid in September 1989 suggest that some fish remain in nearby deep habitats during low-flow periods.

Feeding habits of humpback chub are not well known and were unknown in DNM. Capture of some fish in the interfaces between shoreline eddies and adjacent runs suggests that chubs use these areas for feeding on drift. Stomachs of two humpback chub that died in trammel nets contained hymenopterans and plant debris; and gross examination of fecal material taken from live fish indicates extensive use of hymenopterans and other terrestrial insects (e.g., Mormon crickets) as food. We observed humpback chub and other fishes (e.g., roundtail chub, common carp) feeding on Mormon crickets at the water surface in eddies.

The high numbers of channel catfish in habitats used by humpback chub and roundtail chub and the gross overlap in foods consumed and in feeding habits (Banks 1964, Holden and Stalnaker 1975a, Tyus and Minckley 1988, Tyus and Nikirk 1990) indicate a potential for negative interactions between these fishes. Although the incidence of predation by channel catfish on native fishes is unknown, observations of bitelike abrasions on some chubs collected in DNM suggest channel catfish predation because no other piscivorous fish in that system could have caused such damage. Humpback chub remains were found in channel catfish stomachs from the Little Colorado River (W. L. Minckley, personal communication), and channel catfish are known to consume fish, fish parts, and eggs in DNM (Tyus and Nikirk 1990). Only a few common carp were captured syntopically with humpback chub. However, we speculate that their abundance may also have some negative impact on the native fishes, due perhaps to predation on eggs.

The humpback chub persists in only a few canyons in the Colorado River basin, and planned water development projects may further jeopardize its survival. The Yampa River in DNM supports all native fishes known to have occurred there, including the endangered humpback chub, Colorado squawfish, and razorback sucker (*Xyrauchen texanus*). Existing flows of the Yampa River may be singularly responsible for enabling the persistence of chubs in the Yampa and Green rivers. Alteration of Yampa River flows could reduce the availability or character of chub spawning habitat and presumably adversely affect their reproduction, aid in further proliferation of introduced competitors and predators, and reduce the quality and quantity of usable habitats. Dinosaur National Monument should be considered a refugium for native fishes, and efforts should be made to protect flows of the Yampa River.

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